# Nine Factor Analysis Defining the $PM_{2.5}$ NAAQS Nonattainment Area Boundary for Ravalli County, Montana

Montana Department of Environmental Quality, Winter 2007

## Background

The Montana Department of Environmental Quality (DEQ) has determined that a violation of a federal National Ambient Air Quality Standard (NAAQS) has occurred in Ravalli County, Montana. This determination is based on an analysis of ambient $PM_{2.5}$ (particulate matter less than or equal to 2.5 microns in diameter) monitoring data collected during 2004 through 2006 at two monitoring sites in Hamilton: the Ravalli County Courthouse [AIRS #30-081-0001] and the Sheriff's Lot [AIRS #30-081-0007]. The combined data from these two sites violated the 24-hour $PM_{2.5}$ NAAQS of 35 micrograms per cubic meter ($\mu g/m^3$). Using the '*Nine Factors*' listed in the U.S. Environmental Protection Agency's (EPA) April 1, 2003 guidance memo[1], DEQ evaluated the geographic extent of the proposed $PM_{2.5}$ nonattainment area (NAA) for Ravalli County. EPA's nine factors are:

1. Emissions in areas potentially included versus excluded from the nonattainment area;
2. Air quality in potentially included versus excluded areas;
3. Population density and degree of urbanization including commercial development in included versus excluded areas;
4. Traffic and commuting patterns;
5. Expected growth (including extent, pattern and rate of growth);
6. Meteorology (weather/transport patterns);
7. Geography/topography (mountain ranges or other air basin boundaries);
8. Jurisdictional boundaries (e.g. counties, air districts, Reservations, etc.); and
9. Level of control of emission sources.

Each one of the 'Nine Factor' analyses is explained in the following sections. All information is based upon the most recent, best available data. Where applicable, data representing the counties adjacent to Ravalli County is also included for comparison purposes. An adjacent county, Missoula, is emphasized since air quality monitoring there also revealed a violation of the 24-hour $PM_{2.5}$ NAAQS.

The dominant source of particulate matter in Ravalli County on an annual basis is from area sources since few industrial point sources exist in the county. The primary area sources are residential wood burning, re-entrained crustal material from unpaved roads, and motor vehicle exhaust.

[1] Jeffrey Holmstead. EPA. April 1, 2003. "Designations for the Fine Particle National Ambient Air Quality Standards".

Based on the results of DEQ's Nine Factor Analysis, the Governor of the State of Montana recommends that EPA designate all of Ravalli County as a $PM_{2.5}$ nonattainment area. Similarly, based on the Nine Factor Analysis prepared by the Missoula City-County Health Department (MCCHD), the Governor recommends that EPA designate a large portion of Missoula County as a $PM_{2.5}$ NAA. A portion of the proposed Ravalli County $PM_{2.5}$ NAA boundary (the northern edge) is contiguous to the proposed Missoula $PM_{2.5}$ NAA boundary in order to provide some uniform regulatory control measures while observing the necessary administrative separation.

The proposed Ravalli County $PM_{2.5}$ nonattainment area is the entire county. The legal description is as follows: Beginning at the intersection of the boundary line between Montana and Idaho with the line dividing townships ten (10) and eleven (11) north, range twenty-two (22) west, and running thence in a general southerly direction following said boundary line to an intersection of the summit of the Bitter Root mountains with the continental divide, said intersection being six (6) miles, more or less, northwest of the crossing of the Dehalonega pass; thence running in a general northeasterly direction along the top of the continental divide to an intersection with the summit of the divide between Bitter Root river and Rock creek; thence following the summit of said divide in a northerly direction to its intersection with the north line of township ten (10) north, range eighteen (18) west; thence following the line between township ten (10) north and eleven (11) north, west to the point of beginning.[2]

The DEQ describes geographic planning areas using the Montana State Plane Coordinate System (SPCS), zone 2500, North American Datum 1983 (NAD83), using approximately 25 kilometers (km) by 25 km (625 $km^2$) sized grids, which are roughly 241 $mi^2$. These planning areas are used for air pollution control programs including, but not limited to, nonattainment planning areas. The SPCS coordinate system is easily defined, readily mapped, and recognized federally and globally for describing geographic points and areas.[3]

## Factor 1: Emissions and Air Quality in Adjacent Areas (Including Adjacent Consolidated Metropolitan Statistical Areas (CMSAs) and Metropolitan Statistical Areas (MSAs)

Ravalli County is located in southwestern Montana and extends nearly 100 miles from the Missoula border to Lost Trail Pass at the Idaho border. U.S. Highway 93 is the major north-south highway running through the county. Ravalli County contains the "Bitterroot Valley" which is bounded by the Sapphire Mountains to the east and the Bitterroot Mountains to the west. Figure 1 shows the relationship of Ravalli County to the five adjacent counties in Montana (Beaverhead, Granite, and Missoula) and Idaho (Idaho and Lemhi).

[2] Montana State Legislature. ONLINE: (http://leg.mt.gov/content/mtcode_const/sup_mat_annon/description_of_county_boundaries.pdf).
[3] DEQ. Montana Clean Air Act Section 107(d) Planning Areas Map. Available Upon Request.


**Figure 1. Ravalli and Adjacent Counties in Montana & Idaho.**

Ravalli County does not contain any metropolitan statistical areas (MSA) as defined by the Office of Management and Budget and the entire county can be classified as "rural" based on the EPA's definition of an area containing a population less than 50,000.[4,5] In contrast, Missoula County contains a metropolitan statistical area, Missoula MSA.[6]

The DEQ believes the Ravalli County airshed is not continuous with the Missoula County airshed during stagnant wintertime wind conditions. Specifically, under these conditions, these adjacent airsheds do not exchange significant amounts of air pollution between counties. Table 1 lists the 98th percentile 24-hour $PM_{2.5}$ concentrations that violated the 24-hour $PM_{2.5}$ NAAQS for both Ravalli and Missoula Counties during the 2004 - 2006 time period.

**Table 1. 98th Percentile 24-Hour $PM_{2.5}$ Concentrations in Hamilton & Missoula.**

| City - County | Year | | | Average[2] ($\mu g/m^3$) |
|---|---|---|---|---|
| | 2004 ($\mu g/m^3$)[1] | 2005 ($\mu g/m^3$) | 2006 ($\mu g/m^3$) | |
| Hamilton - Ravalli County[3] | 44.7 | 40.7[3] | 27.8 | 37.7 |
| Missoula - Missoula County[4] | 46.8 | 42.5 | 34.3 | 41.2 |

[1] $\mu g/m^3$ = micrograms per cubic meter.
[2] The final site averages for the 24-hour period were based on the 3 year period from 2004 through 2006.
[3] The current site (30-081-0007) didn't meet data completeness requirements in 2005 because the monitor was moved from the original Ravalli County monitoring site (30-081-0001). The 2005 data represents combined data from both of these sites to estimate the 98th percentile value.
[4] The Missoula $PM_{2.5}$ monitoring site ID is 30-081-0007.

Regardless of the year, the $PM_{2.5}$ concentrations measured in Hamilton were lower than in those Missoula. During the years with concentrations greater than 35 $\mu g/m^3$, Hamilton had about 4% lower concentrations. However, during 2006, the 98th percentile $PM_{2.5}$ concentration was about 19% lower. For the three-year period average, the concentration in Missoula was over 9% higher than for Hamilton. The concentrations and corresponding days that determined the 98th percentile listed in Table 1 are given in Table 2 and are noted by asterisks (*) including any additional days with $PM_{2.5}$ concentrations greater than 20 $\mu g/m^3$ measured at either monitoring site. Any concentration that was affected by wildfires and flagged is noted by "F". The dates that both Hamilton and Missoula monitoring sites collected samples with $PM_{2.5}$ concentrations greater than 35 $\mu g/m^3$ are emphasized in this table by bold font in addition to the corresponding concentrations. Yellow highlighted days indicate $PM_{2.5}$

[4] 65 FR 249. Office of Management and Budget. Standards for Defining Metropolitan and Micropolitan Statistical Areas; Notice. December 27, 2000. ONLINE: (http://www.census.gov/population/www/estimates/00-32997.pdf).
[5] 69 FR 110. EPA. Rural Business Investment Program. June 8, 2004. ONLINE: (http://www.epa.gov/fedrgstr/EPA-IMPACT/2004/June/Day-08/i12731.htm).
[6] U.S. Census Bureau. Current Lists of Metropolitan and Micropolitan Statistical Areas and Definitions. ONLINE: (http://www.census.gov/population/www/estimates/metrodef.html).

concentrations were dissimilar between the two sites.

**Table 2. Dates and $PM_{2.5}$ Concentrations ≥ 20 µg/m$^3$ in Hamilton & Missoula, 2004 – 2006.**

| Date | $PM_{2.5}$ Concentration (µg/m$^3$) | | Date | $PM_{2.5}$ Concentration (µg/m$^3$) | |
|---|---|---|---|---|---|
| | Hamilton | Missoula | | Hamilton | Missoula |
| 1/1/2004 | 44.7*[2] | 28.0 | 1/19/2005 | 1.7 | 62.5* |
| 1/7/2004 | 30.0 | 29.8 | 1/25/2005 | 19.5 | 27.1 |
| **1/10/2004** | **64.0*** | **55.4*** | 1/28/2005 | 15.1 | 25.8 |
| 1/13/2004 | 38.6 | ND[3] | 8/8/2005 | 21.8F[4] | 30.8F |
| **1/16/2004** | **45.5*** | **62.3*** | 8/29/2005 | ND | 24.9F |
| 1/19/2004 | 41.7 | 46.8* | 11/18/2005 | 21.0 | 29.4 |
| 1/22/2004 | 12.2 | 28.0 | 11/21/2005 | ND | 21.2 |
| 2/15/2004 | 7.7 | 30.8 | 11/30/2005 | 3.2 | 20.2 |
| 2/18/2004 | 12.0 | 20.8 | 12/9/2005 | ND | 42.5* |
| 10/27/2004 | ND | 28.3 | **12/12/2005** | **52.8*** | **54.0*** |
| 11/5/2004 | 16.9 | 31.7 | 12/18/2005 | 21.3 | ND |
| 11/11/2004 | 22.0 | 14.8 | 12/24/2005 | 5.2 | 21.8 |
| 11/17/2004 | 15.7 | 22.8 | 2/13/2006 | ND | 24.4 |
| 11/23/2004 | 10.0 | 22.1 | 3/6/2006 | 21.5 | 19.4 |
| 12/14/2004 | 19.9 | 23.5 | 8/30/2006 | ND | 34.3*F |
| 12/17/2004 | 15.4 | 36.6 | 11/28/2006 | ND | 43.2* |
| 12/26/2004 | 19.7 | 25.2 | 12/4/2006 | ND | 21.5 |
| 12/29/2004 | ND | 28.0 | 12/7/2006 | 30.5* | 26.2 |
| 1/4/2005 | 27.7 | 19.2 | 12/10/2006 | ND | 36.2* |
| 1/7/2005 | 29.4 | 10.0 | 12/19/2006 | 27.8* | 17.1 |
| 1/10/2005 | 40.7* | 20.6 | 12/22/2006 | ND | 30.2 |
| 1/16/2005 | 37.3 | 30.8 | | | |

[1] µg/m$^3$ = micrograms per cubic meter.
[2] "*" denotes the values that were used in the 98$^{th}$ percentile compliance calculation.
[3] "ND" = no data collected.
[4] "F" denotes the value was influenced by wildfire, but not eligible for exclusion by EPA.

Over 40% of the days in Table 2 when $PM_{2.5}$ concentrations were greater than 35 µg/m$^3$, the fine particulate concentrations were grossly dissimilar between the two sites when ignoring the influence of wildfires. Almost 35% of the remaining dates, the Missoula $PM_{2.5}$ monitor recorded higher concentrations in comparison to about 24% when Hamilton recorded higher $PM_{2.5}$ concentrations.

As displayed in Table 2, Ravalli County recorded six days greater than 35 µg/m$^3$ over the three years, whereas Missoula County recorded nine days greater than this concentration. Therefore, there were nine total days with $PM_{2.5}$ concentrations greater than 35 µg/m$^3$ measured at both monitoring sites. Three days out of nine (33%) were common for both sites: 1/10/04, 1/16/04, and 12/12/05. On 1/10/04 and 12/12/05, the

concentrations were within about 2% of each other. On 1/16/04, the $PM_{2.5}$ concentration measured in Missoula was about 37% higher than in Hamilton.

Table 3 illustrates the compliance calculation for the annual $PM_{2.5}$ standard of 15.0 $\mu g/m^3$ for both Ravalli and Missoula. Note that the annual means in this table are arithmetic means and not calculated using the required technique as described in 40 CFR Part 50 Appendix N. As seen from Table 3, neither county came close to violating the annual $PM_{2.5}$ standard.

**Table 3. Arithmetic $PM_{2.5}$ Annual Mean Compliance Calculation.**

| City - County | Year | | | Average[2] ($\mu g/m^3$) |
|---|---|---|---|---|
| | 2004 ($\mu g/m^3$)[1] | 2005 ($\mu g/m^3$) | 2006 ($\mu g/m^3$) | |
| Hamilton - Ravalli | 8.53 | 8.94[3] | 8.34 | 8.60 |
| Missoula - Missoula[4] | 10.7 | 11.09 | 9.50 | 10.43 |

[1] $\mu g/m^3$ = micrograms per cubic meter.
[2] The final site averages for the annual standard were based on the 3 year period from 2004 through 2006.
[3] The current site (30-081-0007) didn't meet data completeness requirements in 2005 because the monitor was moved from the original Ravalli County monitoring site (30-081-0001). The 2005 data represents combined data from both of these sites to estimate the annual average value.
[4] The Missoula $PM_{2.5}$ monitoring site ID is 30-081-0007.

The concentrations of $PM_{2.5}$ in the ambient air also include secondary fine particles. Secondary particulates form as a result of the interaction of precursor emissions of ammonia ($NH_3$), nitrous oxides (NOx), sulfur dioxide ($SO_2$), and volatile organic carbons (VOC or VOCs). Therefore, for Factor 1, DEQ reviewed the annual emissions in tons per year (tpy) from these secondary fine particulates in addition to the crustal $PM_{2.5}$ for Ravalli and adjacent counties based on the 2001 National Emission Inventory (NEI) as shown in Table 4. The primary and filterable $PM_{2.5}$ emissions were combined to characterize the crustal $PM_{2.5}$ emissions. Table 4 also displays the proportion of the annual emissions from the surrounding counties relative to the Ravalli County emissions.

The emissions in Table 4 represented four general source categories: point, area, onroad mobile, and nonroad mobile. Onroad mobile emissions occurred on both paved and unpaved roads. The nonroad sources included 2- and 4- stroke and diesel engines, construction equipment, aircraft, and locomotives. Area sources included residential wood combustion (wood stoves, etc.), residential fossil fuel combustion, and agriculture (including field burning). It should be noted that these emissions should be evaluated proportionally since DEQ did not submit state-specific data for the 2001 NEI. The state of Idaho did submit area source data, but only some point source data.

**Table 4. Estimated Emissions of $SO_2$, NOx, VOC, $NH_3$, and $PM_{2.5}$ in 2001 in Ravalli and Adjacent Counties.**[1]

| County - State | State + County FIPS[2] | $SO_2$ (tpy)[3] | Percent of Ravalli (%) | NOx (tpy) | Percent of Ravalli (%) | VOC (tpy) | Percent of Ravalli (%) | $NH_3$ (tpy) | Percent of Ravalli (%) | Crustal $PM_{2.5}$ (tpy) | Percent of Ravalli (%) | Total (tpy) | Percent of Ravalli (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ravalli - MT | 03-081 | 157 | NA[4] | 2,147 | NA | 2,518 | NA | 1,072 | NA | 5,327 | NA | 11,221 | NA |
| Beaverhead - MT | 30-001 | 228 | 145.2 | 1,877 | 87.4 | 2,147 | 85.3 | 3,560 | 332.1 | 3,663 | 68.8 | 11,475 | 102.3 |
| Granite - MT | 30-039 | 166 | 105.7 | 2,038 | 94.9 | 802 | 31.9 | 710 | 66.2 | 1,506 | 28.3 | 5,222 | 46.5 |
| Missoula - MT | 30-063 | 824 | 524.8 | 11,209 | 522.1 | 7,191 | 285.6 | 515 | 48.0 | 7,532 | 141.4 | 27,271 | 243.0 |
| Idaho - ID | 16-049 | 1,441 | 917.8 | 6,267 | 291.9 | 15,473 | 614.5 | 2,455 | 229.0 | 26,472 | 496.9 | 52,108 | 464.4 |
| Lemhi - ID | 16-059 | 749 | 477.1 | 3,188 | 148.5 | 7,686 | 305.2 | 1,947 | 181.6 | 12,350 | 231.8 | 25,920 | 231.0 |

[1] EPA. Criteria Pollutant Emissions Summary Files. 2001. File: sccsummarymade09192005.txt. ONLINE: (ftp://ftp.epa.gov/pub/EmisInventory/nei_criteria_summaries/2001criteriasummaryfiles/).
[2] The five character state and county codes are assigned by the Federal Identification Program System (FIPS).
[3] tpy = tons per year.
[4] NA = Not Applicable.

For the 2001 NEI, only Granite County had less total emissions than Ravalli County. About 50% of the 2001 NEI estimated Ravalli County emissions were crustal and the other fraction was composed of the precursor emissions for secondary particulate formation. The very high Idaho County $PM_{2.5}$ emissions were due to wildfire activities. In comparison to Missoula County, the Ravalli County emissions were about 40%. Table 5 lists the source contributions by pollutant for each county as determined by the 2001 NEI.

**Table 5. Percent Source Contributions to $SO_2$, NOx, VOC, $NH_3$, and $PM_{2.5}$ Emissions in Ravalli & Surrounding Counties.**[1]

| Pollutant | Source Type | Percentage Source Contribution by County (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Ravalli - MT | Beaverhead - MT | Granite - MT | Missoula - MT | Idaho - ID | Lemhi - ID |
| $SO_2$ | Point | 0.0 | 0.4 | 0.0 | 21.8 | 0.2 | 0.0 |
| | Area | 59.3 | 70.7 | 34.3 | 35.8 | 95.3 | 97.2 |
| | Onroad Mobile | 31.8 | 10.5 | 5.4 | 10.6 | 1.2 | 0.9 |
| | Nonroad Mobile | 8.9 | 18.4 | 60.3 | 31.8 | 3.3 | 1.9 |
| NOx | Point | 0.0 | 1.3 | 0.0 | 26.8 | 0.1 | 0.0 |
| | Area | 20.4 | 32.6 | 10.9 | 18.2 | 84.7 | 89.9 |
| | Onroad Mobile | 73.1 | 46.2 | 15.7 | 23.6 | 8.8 | 6.6 |
| | Nonroad Mobile | 6.5 | 19.9 | 73.4 | 31.5 | 6.4 | 3.5 |
| VOC | Point | 0.0 | 0.0 | 0.0 | 14.6 | 0.4 | 0.0 |
| | Area | 58.9 | 74.4 | 67.6 | 51.4 | 95.3 | 91.7 |
| | Onroad Mobile | 33.0 | 17.4 | 17.3 | 24.2 | 1.9 | 1.5 |
| | Nonroad Mobile | 8.1 | 8.2 | 15.1 | 9.8 | 2.4 | 6.8 |
| $NH_3$ | Point | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 |
| | Area | 95.9 | 99.4 | 98.8 | 83.9 | 99.4 | 99.6 |
| | Onroad Mobile | 4.0 | 0.6 | 1.1 | 15.7 | 0.6 | 0.3 |
| | Nonroad Mobile | 0.1 | 0.0 | 0.1 | 0.2 | 0.0 | 0.1 |
| Crustal $PM_{2.5}$ | Point[2] | 0.0 | 0.6 | 0.0 | 22.8 | 0.5 | 0.0 |
| | Area[2] | 99.0 | 97.8 | 96.6 | 74.8 | 99.3 | 99.9 |
| | Onroad Mobile[3] | 0.7 | 0.5 | 0.5 | 0.7 | 0.0 | 0.0 |
| | Nonroad Mobile[3] | 0.3 | 1.1 | 2.9 | 1.7 | 0.2 | 0.1 |

[1] NEI = National Emission Inventory; EPA. Criteria Pollutant Emissions Summary Files. 2001. File: tier3summarymade09082005.txt. ONLINE: (ftp://ftp.epa.gov/pub/EmisInventory/nei_criteria_summaries/2001criteriasummaryfiles/).
[2] Crustal $PM_{2.5}$ point and area included both the primary and filterable $PM_{2.5}$.
[3] Crustal $PM_{2.5}$ onroad and nonroad mobile were primary $PM_{2.5}$ only.

Most of the annual $PM_{2.5}$ emissions in Ravalli County were from area sources, primarily re-entrained road from unpaved roads followed by onroad mobile sources. Over 70% of the Ravalli County NOx emissions were from onroad mobiles sources. Cattle husbandry was almost 84% of the ammonia emissions and almost 40% of the VOCs emissions were from wildfires, which cannot be considered when determining the NAA boundary. In 2001, the Ravalli County had no significant point sources; $PM_{2.5}$ emissions from the current three point sources are discussed in Factor 9.

Another large source of $PM_{2.5}$ emissions in Ravalli County occurs during the spring through fall seasons from wildland fires and prescribed burning activities in the surrounding timber and rangelands. Long distance transport of fire activities in Idaho also impact Ravalli County. Emissions from prescribed burning are currently addressed under the Montana/Idaho State Airshed Group. Emissions from wildfires are also addressed through the Exceptional Events Rule whereby states may flag monitoring data that was adversely influenced by exceptional events, e.g., smoke from wildfires. If EPA concurs with the flagged data, then that data is not considered in compliance decisions, i.e., nonattainment determinations.

Due to the topographical features and meteorology described later, DEQ believes by proposing the entire county as the $PM_{2.5}$ NAA, one captures all of the sources that did or will cause or contribute to exceedances of the 24-hour $PM_{2.5}$ NAAQS in Ravalli County.

## Factor 2: Air Quality in Potentially Included Versus Excluded Areas

During the 2004 - 2006 time period, federal reference method (FRM) $PM_{2.5}$ data was collected in only two of the six counties (Ravalli and Missoula). However, other data sources are available to compare the emission sources in Ravalli and Missoula Counties.

A $PM_{2.5}$ chemical mass balance (CMB) study was conducted in Hamilton from November 7, 2006 through February 27, 2007.[7] The objective was to identify the $PM_{2.5}$ sources in the Bitterroot Valley airshed during the four winter months (November through February) when the highest $PM_{2.5}$ concentrations occur. The CMB study was designed to only collect samples once every six days, but unfortunately, only 11 of the proposed 19 samples were collected due to sampling errors. Therefore, additional samples will be collected during the 2007 - 2008 winter season.

The $PM_{2.5}$ concentrations of the 11 CMB samples averaged 11.6 $\mu g/m^3$ with the highest concentration of 30.5 $\mu g/m^3$ being measured on December 7, 2006. Based on the results of the CMB model runs, on the average, emissions from residential wood combustion (RWC) accounted for 84% (83.6%) of the $PM_{2.5}$ mass, with only 2% explained by automobile emissions. Ammonium nitrate, a secondary particle, averaged 13%. On the highest $PM_{2.5}$ concentration day during the CMB study, RWC and ammonium nitrate averaged approximately 84% and 17%, respectively, of the explained $PM_{2.5}$ mass. The area emissions of ammonia (from cattle) and NOx (from motor vehicles) estimated by the 2000 NEI probably contributed to the ammonium nitrate identified by this CMB study.

Simultaneously with the Hamilton CMB study another CMB study was conducted in

[7] Ward, Tony J. August 1, 2007. The Hamilton, Montana $PM_{2.5}$ Source Apportionment Research Study. Center for Environmental Health Sciences. The University of Montana – Missoula. Skaggs Building 17B. Missoula MT 59812.

Missoula.[8] Again, the objective was to identify the emission sources and estimate their contributions to the ambient $PM_{2.5}$ concentrations measured in the Missoula Valley during the four winter months of November, December, January and February. Just like most of western Montana, including the Bitterroot Valley, this is the period when the highest $PM_{2.5}$ concentrations occur, except for those years with bad wildfires during the summer months. In the Missoula CMB study, 26 samples were successfully collected and analyzed.

The $PM_{2.5}$ concentrations of the 26 Missoula CMB samples averaged 15.4 $\mu g/m^3$ with the highest concentration of 43.2 $\mu g/m^3$ being measured on November 28, 2006. Unfortunately for comparison purposes, a corresponding Hamilton CMB sample was not collected the same day. Based on the results of the CMB model runs, on the average, emissions from RWC accounted for 56% (55.5%) of the $PM_{2.5}$ mass, with only 1% explained by automobile emissions. Ammonium nitrate, a secondary particle, averaged 19%. On the highest $PM_{2.5}$ concentration day during the Missoula CMB study, RWC and ammonium nitrate contributed approximately 60% and 10%, respectively of the explained $PM_{2.5}$ mass. On December 7, 2006, the day that measured the highest $PM_{2.5}$ concentration during the Hamilton CMB study, an error occurred in the data at the Missoula CMB site.

Four emission source profiles were common to both CMB studies: automobiles, ammonium nitrate, RWC and street sand. The Hamilton study used one other source profile, secondary sulfate, and about 2% of the average $PM_{2.5}$ concentration was attributed to that emission source profile. It is important to note that secondary sulfate particles are not directly emitted by sources, but form in the atmosphere. The Missoula CMB study identified three different emission sources that were relatively significant contributing sources to the ambient $PM_{2.5}$ concentrations in Missoula. These three sources were NOT identified in the Hamilton CMB study. These three sources and their relative contributions were:

- Diesel (~ 5%)
- Kraft recovery boiler (~ 7%), and
- Hog fuel boilers (~ 12%).

Relative to Hamilton, the diesel contribution is explained by the differences in motor vehicle populations (long haul heavy duty truck traffic on Interstate 90) and the presence of a main railroad line (with switching yard) in the Missoula Valley. A major point source in the Missoula Valley, Smurfit-Stone Container Corporation, uses both types of boilers that were identified in the CMB study. The diesel and the boiler emission source profiles were NOT identified in the Hamilton CMB analyses. This fact indicates there is very little or no exchange of air between the Missoula and Bitterroot Valleys during the wintertime when the highest $PM_{2.5}$ concentrations are traditionally monitored.

[8] Ward, Tony J. September 1, 2007. The Missoula, Montana $PM_{2.5}$ Source Apportionment Research Study. Center for Environmental Health Sciences. The University of Montana – Missoula. Skaggs Building 17B. Missoula MT 59812.

## Factor 3: Population Density and Degree of Urbanization Including Commercial Development In Included Versus Excluded Areas

According to the 2000 U.S. Census, Ravalli County had a total area of 2,394.21 square miles (mi²) or 6,201.00 square kilometers ($km^2$). The total 2000 population was 36,070 residing in 14,289 occupied households (15,496 total housing units or 92% occupancy) within 10,182 families. Using this information for 2000, the population density is estimated to be approximately 15.1/$mi^2$ (5.8/km²) with an average housing density of approximately 6.5/$mi^2$ (2.5/km²).[9] However, only about 25% of the land in Ravalli County is privately-owned, therefore the population and average housing densities was actually about 60/$mi^2$ and 26/$mi^2$, respectively, in the year 2000. The 2000 U.S. Census data relating to population, number of housing units, number of occupied housing units, and percentage of occupancy for the seven communities in Ravalli County is provided in Table 6.

**Table 6. Ravalli Community, Population & Housing Unit Occupancy Data, 2000.**[1]

| Community | Population | Number of Housing Units | Number of Occupied Housing Units | Percent Housing Occupancy (%) |
|---|---|---|---|---|
| Corvallis CDP[2] | 443 | 198 | 185 | 93.4 |
| Darby Town[3] | 710 | 2,316 | 279 | 88.3 |
| Florence CDP | 901 | 336 | 323 | 96.1 |
| Hamilton City[4,5] | 3,705 | 1,915 | 1,772 | 92.5 |
| Pinesdale Town | 742 | 149 | 139 | 93.2 |
| Stevensville Town | 1,553 | 711 | 652 | 91.7 |
| Victor CDP | 859 | 375 | 351 | 93.6 |

[1] U.S. Census Bureau Quickfacts Report. 2000. Table DP-1. Profile of General Demographic Characteristics: 2000. ONLINE: (http://quickfacts.census.gov/cgi-bin/qfd/demolink?30).
[2] CDP = Census Designated Place(s); a geographic unincorporated place; a statistical definition assigned by the Office of Management and Budget (OMB) and used by the U.S. Census Bureau.
[3] Town = a type of geographic incorporated place with local government; a statistical definition assigned by the Office of Management and Budget (OMB) and used by the U.S. Census Bureau.
[4] City = a type of geographic incorporated place with local government; a statistical definition assigned by the Office of Management and Budget (OMB) and used by the U.S. Census Bureau.
[5] County seat.

The total 2000 population of these seven communities was 8,913 or about 25% of the

[9] Census and Economic Information Center. Montana Department of Commerce.Demographic & Economic Information for Ravalli County. ONLINE: (http://www.ourfactsyourfuture.org/admin/uploadedPublications/1598_Ravalli_CF06_Web.pdf).

Ravalli County total. Currently, there are only four incorporated towns in Ravalli County: Darby, Hamilton, Pinesdale, and Stevensville. Together in 2000, these four communities contained about 19% of the Ravalli County population. Another six communities are located in Ravalli County, but were not listed in Table 6 since 2000 U.S. Census data were unavailable: Alta, Connor, Grantsdale, Lost Trail Camp, Sula, and Woodside. All communities are included in the proposed $PM_{2.5}$ Ravalli County nonattainment area.

Table 7 provides the land area, estimated 2004 though 2006 populations, and 2006 population densities for Ravalli and adjacent counties. Most of these counties had very low population densities (~2 people/$mi^2$) except for Ravalli and Missoula Counties. In those two counties the population densities are significantly higher (~ 8.5 times higher), and the Missoula County population density was two times higher than Ravalli County. Approximately 75% of the land in Ravalli County is public, mostly U.S. Forest Service, with only about 25% privately owned (Figure 2). Thus, the potential for commercial and residential development is relatively limited in Ravalli County.

**Table 7. Land Area and Population for Ravalli & Adjacent Counties.**

| County - State | Land Area ($mi^2$)[1] | 2004 Population | 2005 Population | 2006 Population | 2006 Density (persons/$mi^2$) |
|---|---|---|---|---|---|
| Ravalli - MT[2, 3] | 2,394.21 | 39,417 | 39,822 | 40,582 | ~ 17 (16.95) |
| Beaverhead - MT[2, 3] | 5,542.31 | 8,832 | 8,778 | 8,743 | < 2 (1.58) |
| Granite - MT[2, 3] | 1,727.44 | 2,893 | 2,932 | 2,909 | < 2 (1.68) |
| Missoula - MT[2, 3] | 2,597.97 | 99,031 | 100,033 | 101,417 | ~ 39 (39.04) |
| Idaho - ID[4, 5] | 8,484.88 | 15,637 | 15,659 | 15,762 | < 2 (1.86) |
| Lemhi - ID[4, 5] | 4,564.16 | 7,827 | 7,868 | 7,930 | < 2 (1.74) |

[1] $mi^2$ = square mile.
[2] Census and Economic Information Center. Montana Department of Commerce. 2000 U.S. Census. CENSUS 2000 PUBLIC LAW 94-171 REDISTRICTING DATA – PLACE. ONLINE: (http://ceic.mt.gov/C2000/PL2000/PLcountyarea.pdf).
Census and Economic Information Center. Montana Department of Commerce. Components of Change and Total Population. Table 1. Annual Estimates of the Population, 2000-2006. ONLINE: (http://ceic.mt.gov/Demog/estimate/pop/County/CO-EST2006-01-30.htm).
[4] U.S. Census Bureau. 2000 U.S. Census. State and County QuickFacts. ONLINE: (http://quickfacts.census.gov/qfd/states/16000.html).

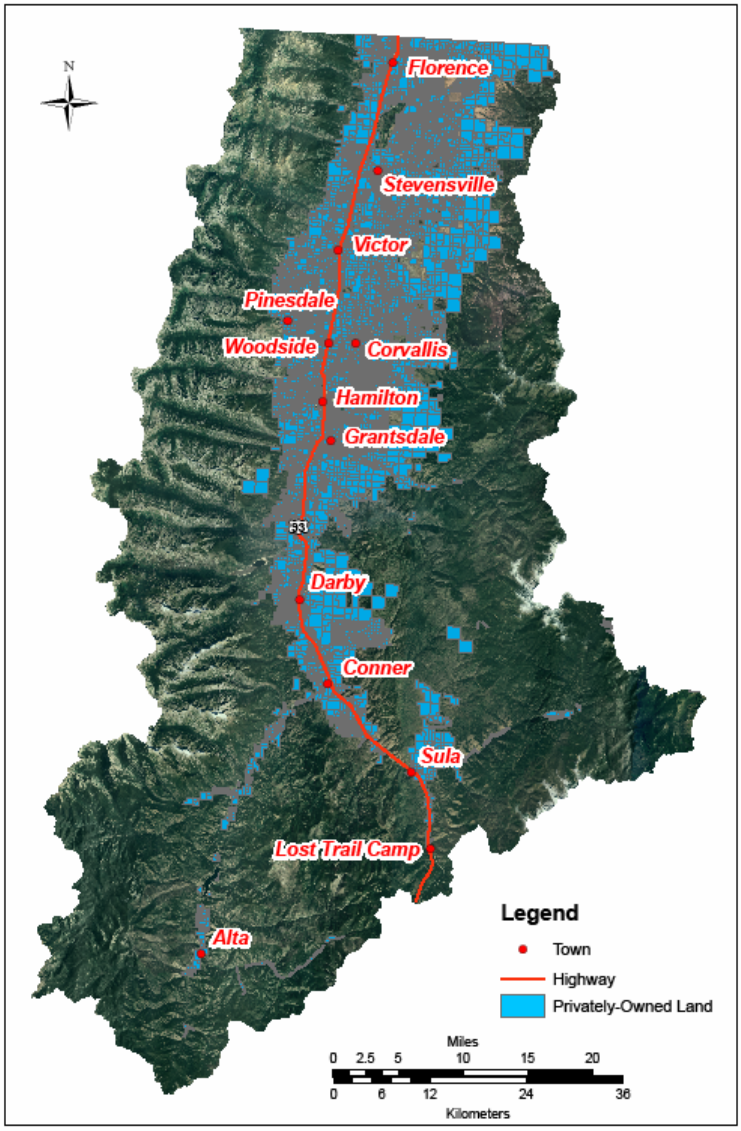


**Figure 2. Privately Owned Land in Ravalli County.**

The Missoula City-County Health Department provided the maps that are displayed in Figure 3. Although the entire Ravalli County was not included, the northern-most area adjacent to Missoula County is displayed. The red areas primarily indicate residences.

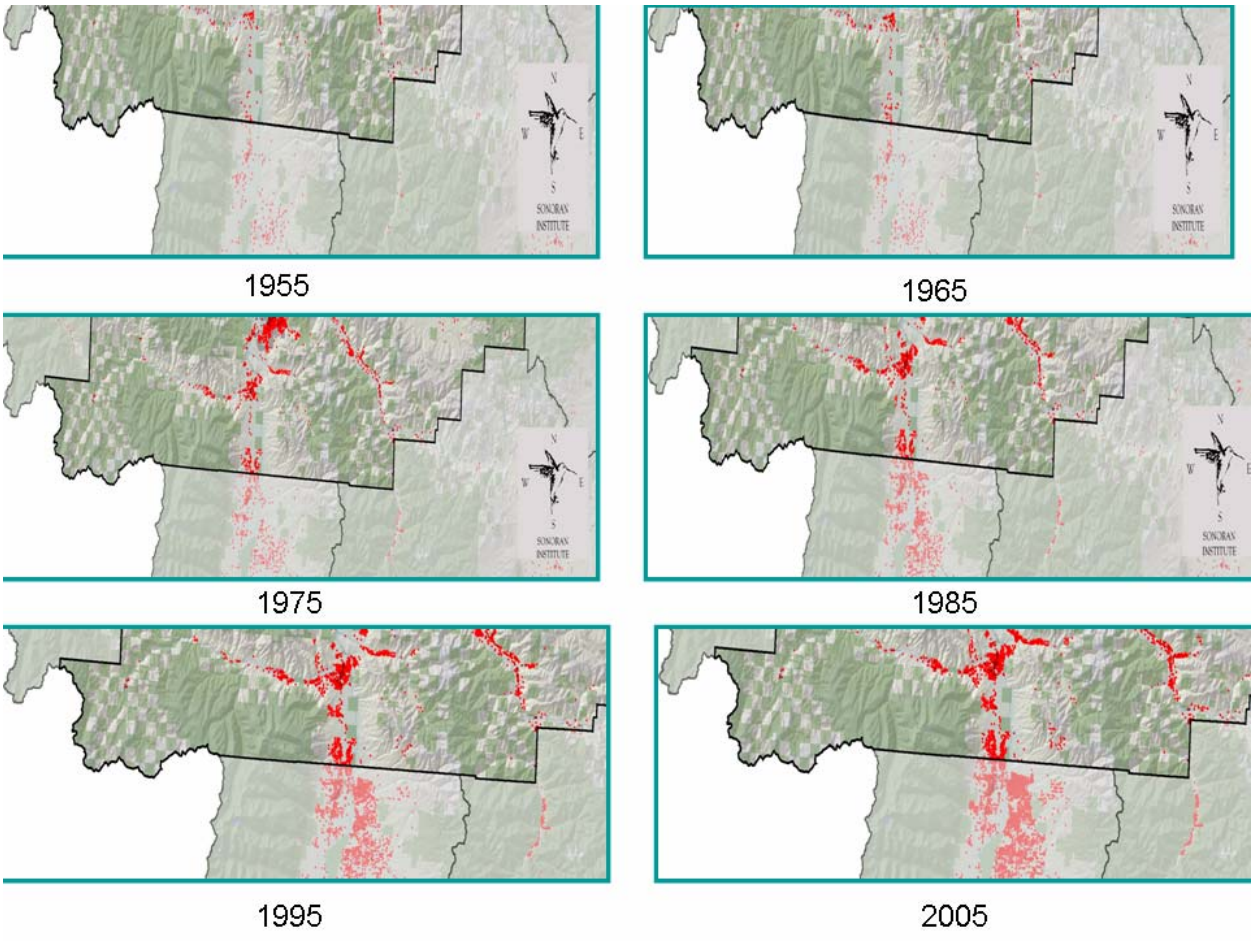


**Figure 3. Growth Patterns in Northern Ravalli County, 1955 - 2005.**[1]

[1] Courtesy: Sonoran Institute.

As seen in Figure 3, heavy residential development has occurred south of Missoula into Ravalli County, particularly the eastern side of the county. Some land looks open for growth, but Ravalli County is still in the process of developing the zoning regulations (http://www.ravallicounty.mt.gov/planning/Zoning.htm).

Historically, the economy of Ravalli County relied predominantly on agriculture and timber. Logging operations supplied lumber to support area mining activities. However, the current Ravalli County economy primarily stems from retail trade. Other significant sectors include:

- Health Care and Social Assistance,
- Educational Services, Manufacturing, and
- Accommodation & Food Services (related to tourism).

However, the sectors that have seen the most growth in recent years are related to wholesale trade. They include Arts, Entertainment and Recreation, Mining, and

Construction, all of which have shown double-digit growth from 2004 to 2005.[10]

The new business growth in Ravalli County indicates commercial and industrial development. Table 8 lists the number of business establishments, number of employees, and sales receipts for Ravalli County in 1992, 1997, and 2002.

**Table 8. Business Growth in Ravalli County: 1992, 1997, and 2002.**[1]

| Business Characteristic | 1992 | 1997 | 2002 | 1992 – 1997 Annual Percent Increase (%) | 1992 – 2002 Annual Percent Increase (%) |
|---|---|---|---|---|---|
| Number of Establishments | 504 | 624 | 843 | 4.8 | 6.7 |
| Number of Employees | 3,400 | 4,433 | 5,685 | 6.1 | 6.7 |
| Sales Receipts ($Million) | 320 | 525 | 625 | 9.5 | 9.5 |

[1] U.S. Census Bureau. 1992. ONLINE: (http://www.census.gov/epcd/www/92profiles/county/30081.TXT).
[2] U.S. Census Bureau. 1997. ONLINE: (http://www.census.gov/epcd/ec97/mt/MT081.HTM).
[3] U.S. Census Bureau. 2002. ONLINE: (http://www.census.gov/econ/census02/data/mt/MT081.HTM).

Over the ten year period from 1992 to 2002, Ravalli County had about a 7% annual increase in both number of establishments and employees, and 10% increase in million dollar sales receipts. However, as discussed earlier, most of these businesses were tourist-related with some construction and manufacturing. Based on the analysis for this factor, commercial development was and will probably continue to be limited due to unavailable land.

## Factor 4: Traffic and Commuting Patterns

Ravalli County serves as a 'bedroom' community to the more urban northern Missoula area since Hamilton, the largest town in Ravalli County, is less than 50 miles away. Motor vehicle traffic movement north and south along U.S. Highway 93 is significant since alternative forms of transportation such as public transportation (bus service) is limited and light rail is nonexistent. Vehicle exhaust, and tire and brake wear are all

[10] Census and Economic Information Center. Montana Department of Commerce. Research & Analysis Bureau. Demographics & Economic Information for Ravalli County. ONLINE: (http://www.ourfactsyourfuture.org/admin/uploadedPublications/1598_Ravalli_CF06_Web.pdf).

sources of $PM_{2.5}$; therefore, the commuting pattern of the Ravalli County residents is important to characterize.

The most recent ten years of data from the Montana Department of Transportation's (MDT) Automatic Traffic Recorders (ATR) on U.S. Highway 93 between Ravalli and Missoula Counties was analyzed. There were two ATR sites in Ravalli County:

- A-47 (north of Stevensville, which is closer to Missoula) and
- A-56 (north of Hamilton).

No ATR sites exist on U.S. Highway 93 between Missoula and the Ravalli County line. Table 9 lists the annual average daily traffic (AADT) for these sites for 1997 through 2006. It should be noted that the AADTs were adjusted by MDT for the time of year and day of the week.

**Table 9. Annual Average Daily Traffic Growth on U.S. Highway 93, Ravalli County, 1997 – 2006.**

| Traffic Counter Code& Location | Year of AADT[1] | | | | | | | | | | Annual Percent VMT Change (%)[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | |
| A-47, north of Stevensville | 7,973 | 8,8336 | 8,873 | 8,989 | 9,322 | 9,625 | 9,907 | N/A[3] | N/A | 9,477 | 1.94 |
| A-56, north of Hamilton | 9,795 | 10,211 | 10,605 | 10,605 | 10,741 | 11,078 | 11,183 | 11,333 | 11,243 | 11,352 | 1.65 |

[1] AADT = annual average daily traffic; MDT. Statistics and Data. Montana's Automatic Traffic Recorders 2006. ONLINE: (http://www.mdt.mt.gov/publications/docs/datastats/atr/atrbook06.pdf).
[2] Annual VMT change = (EXP((LN(D12/D11))/(C12-C11)))-1 (Cyra Cain, DEQ, personal communication, Al Vander Wey, Montana Department of Transportation, 2005).
[3] N/A = Not Available.

In 2006, the ATR site closest to Missoula County (A-47) had lower AADT by about 17% than site A-56 which is further south in Ravalli County. However, the annual VMT growth was slightly higher at the more northern site (A-47) in Ravalli County. Taken together, the average VMT percent change for the two ATR sites in Ravalli County was approximately 1.80%. MDT's rural traffic flow map for Ravalli County with 2005 AADT data is shown in Figure 4. The map shows

slightly different traffic values than the recorders, but the traffic pattern is similar. The 2005 AADT map also shows data for traffic flow south of Hamilton. The numbers over the routes indicate total AADT with the truck AADT numbers listed underneath.


The AADT on U.S. Highway 93 between Hamilton and Connor (at the junction of US 93 and S-473) decreased significantly to approximately a third of the volume north of Hamilton. Continuing south to the Idaho border, the AADT decreased by approximately 75%.

**Figure 4. Rural Traffic Patterns in Ravalli County, 2005.**[1]

[1] MDT. Montana Maps. 2005 Rural Traffic Flow Map. ONLINE: (http://www.mdt.mt.gov/travinfo/docs/2005_traffic_flow_map.pdf).

Another indicator of traffic patterns is the 'commuting to work characteristics' obtained from the 2000 U.S. Census. The U.S. Census Bureau classifies workers as 18 years and older. Table 10 gives the 2000 U.S. Census data pertaining to number of workers and their commuting patterns in Ravalli and adjacent counties.

**Table 10. Commuting Patterns in Ravalli and Adjacent Counties.**[1]

| County - State | Total Number of Workers | Number Working in Home County | Number Commuting to Ravalli County | Percent Commuting to Ravalli County (%) | Percent of Ravalli Workers Commuting to Other Counties (%) |
|---|---|---|---|---|---|
| Ravalli - MT | 15,362 | 11,766 | NA[2] | NA | NA |
| Beaverhead - MT | 4,403 | 4,126 | 5 | 0.1 | < 0.0 |
| Granite - MT | 1,261 | 929 | 3 | 0.2 | 0.0 |
| Missoula - MT | 49,448 | 47,159 | 900 | 1.8 | 20.6 |
| Idaho - ID | 5,788 | 4,870 | 0 | 0.0 | 0.0 |
| Lemhi - ID | 3,097 | 2,999 | 0 | 0.0 | 0.0 |

[1] U.S. Census Bureau. County-to-County Worker Flow Files. 2000. ONLINE: (http://www.census.gov/population/www/cen2000/commuting.html).

Approximately 77% of the Ravalli County workers were employed in their home county while 21% (3,178) commuted to Missoula County. The remaining Ravalli County workers worked outside the area of interest. The Ravalli workers commuting to Missoula accounted for approximately 71% (6,356) of the 8,989 AADT in 2000 (Table 9). This projection is based on two assumptions:

- The 3,178 Ravalli County commuters did not carpool and
- They worked a traditional schedule (5 days/week and 50 weeks/year)

Essentially, the workers in the other adjacent counties did not commute to Ravalli County to work.

## Factor 5: Growth Rates And Patterns

Ravalli County is projected to have the greatest population growth rate compared to the other adjacent counties, followed by Missoula County. The other adjacent counties are projected to have very low population growth rates. Table 11 shows the projected populations for Ravalli and adjacent counties from 2000 through 2030 in 5-year increments.

**Table 11: Projected Populations for Ravalli & Adjacent Counties, 2000-2030, in 5-Year Increments.**

| County - State | U.S. Census | Estimated Census Data | | | | | | 2000 – 2030 Annual Percent Increase |
|---|---|---|---|---|---|---|---|---|
| | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 | 2030 | |
| Ravalli - MT[1] | 36,070 | 39,940 | 44,710 | 50,100 | 55,500 | 60,960 | 66,670 | 2.83 |
| Beaverhead - MT[1] | 9,202 | 8,773 | 8,920 | 9,260 | 9,630 | 10,070 | 10,570 | 0.50 |
| Granite - MT[1] | 2,830 | 2,965 | 3,160 | 3,250 | 3,360 | 3,510 | 3,670 | 0.99 |
| Missoula - MT[1] | 95,802 | 100,086 | 107,190 | 115,080 | 123,310 | 132,010 | 141,370 | 1.59 |
| Idaho - ID[2] | 15,470 | 15,800 | 15,480 | 15,780 | 15,960 | 16,030 | 15,980 | 0.11 |
| Lemhi - ID[2] | 7,750 | 7,940 | 8,430 | 9,060 | 9,660 | 10,200 | 10,720 | 1.28 |

[1] Census and Economic Center. Montana Department of Commerce. Montana Population Projections, Total Population. Source: NPA Data Services Inc. ONLINE: (http://ceic.mt.gov/Demog/project/NPAallcounties_1106_web.pdf ).
[2] Alan Porter. Department of Labor. State of Idaho. Population Projections. October 3, 2007.

From 1970 to 2000, Ravalli County was one of the five fastest growing counties in Montana. The 1990s witnessed the largest population increases in Ravalli County and statewide. In the decade between 1990 and 2000, Ravalli County's population jumped by 44.2%, from 25,010 to 36,940. Montana's increased statewide from 799,065 to 902,195, a respectable 12.9% increase.

According to the Montana Department of Commerce's Census and Information Center (CEIC), from 1970 to 2000, Ravalli County experienced 178% increase in population in unincorporated areas compared to a 74% population increase in incorporated areas.[11] Interestingly, from 2000 through 2005, the percentages have changed and a higher proportion of the population is moving into incorporated areas (19%) compared to unincorporated ones (9%).[12]

Hamilton was the biggest town (population 2,499) at the start of that 1970 to 2000 period and it was still the largest with 4,443 people in 2000. Stevensville started that period with 829 people and ended with 1,553. Darby began with 538 and ended with 710. The first U.S. Census data for Pinesdale was collected in 1990 with a population of 670 being recorded. By 2000, Pinesdale's population had grown to 832 people.

## Factor 6: Meteorology

The Missoula and Bitterroot Valleys have much in common, but some significant and important differences exist as well. Both valleys are located west of the Continental Divide, both have steep slopes limiting lateral dispersion, and both are subject to intense and long lasting stagnation periods with strong persistent temperature inversions in the lower atmosphere. These stagnation periods are the root cause of the high $PM_{2.5}$ ambient levels that have been monitored in both areas.

Except for wildfire episodes during some summers, the highest $PM_{2.5}$ concentrations were measured during the winter months when these temperature inversions are the strongest and most persistent. The problematic winter inversions are surface based during the night and elevated during the day. The inversions are typically very strong (+ 3 ºC/100 meters or more) for the lowest 200 meters of the atmosphere during the nighttime hours into the early morning. During the late morning and afternoon, the atmosphere near the surface becomes somewhat adiabatic or at least isothermal for the lower 200-300 meters allowing some vertical mixing, but an elevated inversion remains in place trapping the pollutants in the valley over a period of several days, allowing the particulate levels to steadily rise until a synoptic event flushes the air out of the valley. During the nighttime hours when the surface-based inversion is the strongest, vertical mixing is almost nonexistent.

Smoke and other pollutants from area sources such as cars and woodstoves are trapped in a very shallow (10 - 30 meters) layer near the surface. This produces the characteristic "spike" of high hourly $PM_{2.5}$ concentrations during the nighttime hours and during the morning commute.

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[11] Census and Economic Information Center. INCORPORATED VERSUS UNINCORPORATED AREAS PERCENT CHANGE 1970 – 2000. ONLINE: (http://www.ceic.mt.gov/graphics/Data_Maps/IncVsUninc1970-2000.pdf).

[12] Census and Economic Information Center. What the Numbers Say. ONLINE: (http://www.ceic.mt.gov/Publications/Newsletter_Fall_Winter_06_07_Final.pdf).

Because of the vertical mixing issue, lateral dispersion is also severely limited during this period with many hours of "calm" wind speeds recorded at the surface. Winds aloft are totally decoupled from the surface by the stable inversion layer and there is almost no net transport of air out of either valley. Under these conditions, even "regional scale" pollutants like $PM_{2.5}$ with high residence times aloft become local issues with steep lateral concentration gradients as pollution stays very near the emission sources. Diurnal drainage flows are the only sources of air movement under these conditions and they do little to provide any net transport. The bottoms of both valleys are relatively flat and, once minor flows reach the valley floors from the side canyons, downslope gravity winds are minimal.

The three big differences between the Bitterroot and Missoula Valleys are:

- SIZE
- SHAPE
- ORIENTATION

The Bitterroot is long, narrow, and oriented north/south. The Missoula valley is more bowl-shaped with five drainages converging before exiting out to the northwest. The minor amounts of drainage flows reaching the Missoula Valley from the Bitterroot under inversion conditions are very shallow and skirt the west edge of Missoula Valley in the low terrain before heading out past Frenchtown through the Clark Fork River Canyon. This physical separation of air from the Bitterroot Valley from the city of Missoula is why the CMB results from the two areas are so dissimilar. Specific weather analysis was evaluated and presented below.

Since the highest $PM_{2.5}$ concentrations consistently occur during the winter months, this factor analysis focused on the months January, February, and December. Table 12 lists the minimum, maximum, and average ambient air temperatures by month and county for each year 2004 through 2006. The codes representing the sites in this table and other tables in this section are either WBAN (Weather-Bureau-Army-Navy) or COOP (Cooperative). The 5-digit WBAM acronym is used at National Climatic Data Center for digital data storage and general station identification purposes. The Philipsburg Ranger Station ID is a WIMS (Weather Information Management System) code. Further analysis of the specific meteorological conditions that occur during high $PM_{2.5}$ concentration events is investigated later in this section.

## Table 12: Wintertime Ambient Air Temperatures in Ravalli & Adjacent Counties, 2004 – 2006.

| County – State (Site, ID) | Year | Ambient Air Temperature (ºF)[1] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Minimum | | | Maximum | | | Average | | |
| | | January | February | December | January | February | December | January | February | December |
| Ravalli - MT (Stevensville, 247894)[2] | 2004 | 14.2 | 22.4 | 20.8 | 29.6 | 42.9 | 38.8 | 23.1 | 31.0 | 31.1 |
| | 2005 | 13.4 | 17.0 | 12.6 | 35.5 | 46.1 | 30.0 | 29.1 | 29.4 | 24.2 |
| | 2006 | 27.5 | 22.1 | 19.9 | 44.1 | 41.9 | 34.2 | 35.0 | 31.2 | 24.1 |
| Beaverhead - MT (Dillon Airport, 24138)[3] | 2004 | 11.4 | 16.9 | 17.8 | 30.1 | 36.4 | 39.0 | 20.8 | 26.7 | 28.4 |
| | 2005 | 12.6 | 17.2 | 11.6 | 33.9 | 44.3 | 29.3 | 23.3 | 30.8 | 20.5 |
| | 2006 | 19.7 | 13.4 | 14.4 | 37.3 | 36.2 | 36.1 | 28.5 | 24.8 | 25.3 |
| Granite - MT (Philipsburg Ranger Station, 243002)[2] | 2004 | 13.4 | 15.0 | 19.9 | 31.1 | 34.3 | 37.1 | 23.8 | 23.9 | 29.1 |
| | 2005 | 14.7 | 15.1 | 12.2 | 34.4 | 42.0 | 30.7 | 26.0 | 27.6 | 23.8 |
| | 2006 | 25.5 | 13.1 | 14.3 | 38.9 | 34.7 | 32.5 | 31.2 | 23.4 | 23.6 |
| Missoula - MT (Missoula International Airport, 24153)[3] | 2004 | 14.8 | 21.9 | 22.9 | 27.0 | 36.8 | 36.5 | 20.9 | 29.4 | 29.7 |
| | 2005 | 14.5 | 20.2 | 12.6 | 29.5 | 41.5 | 26.5 | 22.0 | 30.9 | 19.6 |
| | 2006 | 27.7 | 18.8 | 18.9 | 40.3 | 36.9 | 32.7 | 34.0 | 27.9 | 25.8 |
| Idaho - ID (Grangeville, 24139)[3] | 2004 | 24.1 | 25.4 | 26.0 | 35.4 | 39.3 | 40.5 | 30.0 | 32.6 | 33.4 |
| | 2005 | 24.5 | 24.4 | 21.0 | 39.2 | 44.3 | 35.0 | 32.1 | 34.5 | 28.3 |
| | 2006 | 30.1 | 22.7 | 22.3 | 42.6 | 39.6 | 37.5 | 36.6 | 31.4 | 30.2 |

[1] ºF = degrees Fahrenheit.
[2] Western Regional Climate Center. Monthly Summary. ONLINE: (http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?mtMSTE).
[3] National Climatic Data Center. Monthly Summary. ONLINE: (http://www.ncdc.noaa.gov/oa/ncdc.html).
[4] Incomplete data set, seven missing days.

Most of the average ambient air temperatures recorded in Ravalli County (Stevensville Ranger Station) during the winter months in 2004 through 2006 were higher than the corresponding temperatures measured at the Missoula International Airport in Missoula County. The one exception was the January average minimum air temperatures. In this case, the Stevensville Ranger Station temperatures were consistently lower than at the airport in Missoula. The ranger station and the airport elevations are 3,365 feet (~1,026 meters) and 3,192 feet (~973 meters), respectively, a difference of 173 feet (~53 meters). One would expect ambient air temperatures to decrease with increasing elevation. These data may indicate that the Missoula valley is experiencing atmospheric inversion layer conditions in which colder air is being trapped by warmer upper air conditions. The graphic representations of the each wintertime month (January, February, and December) minimum, average, and maximum ambient air temperatures by county for the years 2004 through 2006 are shown in Figure 5.

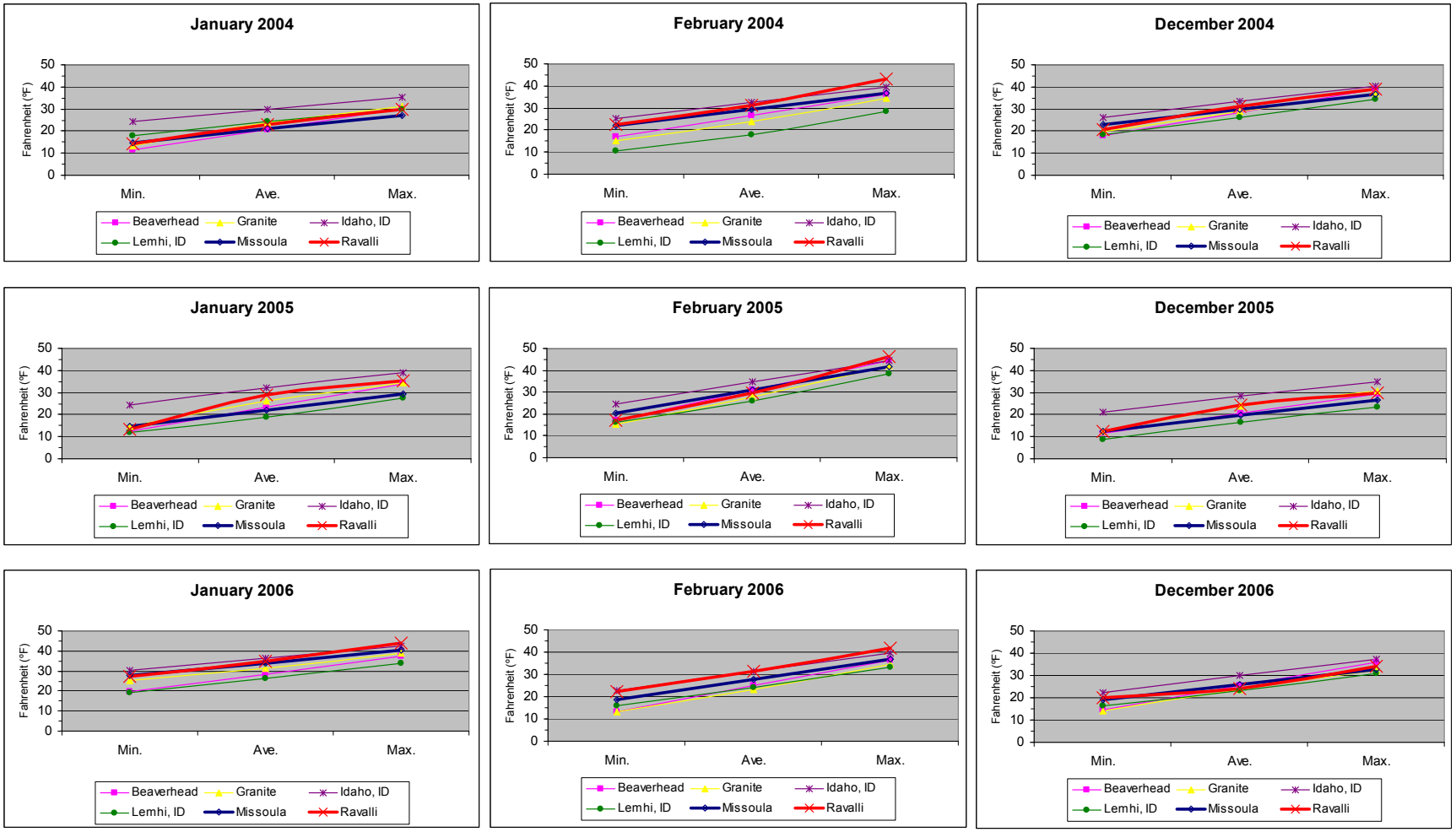


**Figure 5. Minimum, Maximum and Average Winter Ambient Air Temperatures in Ravalli & Adjacent Counties, 2004 – 2006.**

Table 13 provides the average prevailing wind directions and speeds for the combined winter months by county. The dominant wind directions for Ravalli County were from the south (25%) followed by southeast (16%), north (16%), and northeast (15%), respectively. Salmon (the seat of Lemhi County) is the closest substantial town south of Ravalli County, and Salmon is approximately 30 miles south of the Montana/Idaho border. For the Missoula Valley, the dominant wind directions were from the northwest, west, and southeast, respectively, and none of those directions toward Ravalli County. For the other adjacent Montana counties, the dominant wind direction was from the south. This analysis indicates that $PM_{2.5}$ emissions within the adjacent counties do not significantly contribute to the high $PM_{2.5}$ levels in Ravalli County.

**Table 13. Prevailing Wintertime Wind Directions and Speeds for Ravalli & Adjacent Counties, 2004 – 2006.**

| County - State(Site, ID) | Wind Direction (%) | | | | | | | | Average Wind Speed (mph)[1] |
|---|---|---|---|---|---|---|---|---|---|
| | N | NE | E | SE | S | SW | W | NW | |
| Ravalli - MT (Stevensville, 247894)[2] | 15.9 | 15.0 | 11.9 | 16.0 | 25.2 | 9.3 | 2.1 | 4.6 | 2.5[3] |
| Beaverhead - MT (Dillon Airport, 24138)[4] | 0.4 | 5.6 | 3.0 | 2.2 | 46.4 | 42.0 | 0.4 | 0.0 | 9.0 |
| Granite - MT (Phillisburg Ranger Station, 243002)[2] | 4.7 | 7.4 | 9.3 | 19.5 | 51.0 | 5.4 | 2.3 | 0.4 | 3.7 |
| Missoula - MT (Missoula International Airport, 24153)[4] | 8.1 | 2.2 | 11.4 | 19.9 | 7.8 | 4.8 | 21.4 | 24.4 | 3.7 |
| Idaho - ID (Grangeville, 24139)[4, 5] | 1.2 | 8.0 | 13.2 | 13.2 | 12.7 | 36.8 | 13.3 | 1.6 | 7.6 |
| Lemhi - ID (Salmon County Airport, 24196)[4] | 75.4 | 2.0 | 2.8 | 7.0 | 5.5 | 3.8 | 1.9 | 1.6 | 3.2 |

[1] mph = miles per hour.
[2] RAWS USA Climate Archive. ONLINE: (http://www.raws.dri.edu/).
[3] December 2006 data were unavailable.
[4] National Climatic Data Center. Monthly Summary. ONLINE: (http://www.ncdc.noaa.gov/oa/ncdc.html).
[5] Data were only available for December 2005, and January and February 2006.

For the final meteorological analysis, the air temperature data from days in Ravalli County with $PM_{2.5}$ concentrations ≥ 35

$\mu g/m^3$ were evaluated. In addition, the air temperature data from the three corresponding high $PM_{2.5}$ concentration days in Missoula was also evaluated. Table 14 lists the corresponding minimum, maximum, and average ambient air temperatures for the days of interest.

**Table 14. Air Temperature Data on High $PM_{2.5}$ Concentration Dates in Ravalli & Missoula Counties, 2004 – 2006.**

| County (Site, ID) | Date | Ambient Air Temperature (ºF)[1] | | |
|---|---|---|---|---|
| | | Minimum | Maximum | Average |
| Ravalli (Stevensville, 247894)[2] | 1/01/04 | 7 | 20 | 15 |
| | 1/10/04 | 11 | 28 | 18 |
| | 1/16/04 | 14 | 38 | 23 |
| | 1/10/05 | 11 | 25 | 17 |
| | 1/16/05 | 4 | 20 | 13 |
| | 12/12/05 | 2 | 20 | 10 |
| Missoula (Missoula International Airport, 24153)[3] | 1/10/04 | 11 | 26 | 19 |
| | 1/16/04 | 13 | 30 | 22 |
| | 12/12/05 | 23 | 42 | 33 |

[1] ºF = degrees Fahrenheit.
[2] RAWS USA Climate Archive. ONLINE: (http://www.raws.dri.edu/).
[3] National Climatic Data Center. Monthly Summary. ONLINE: (http://www.ncdc.noaa.gov/oa/ncdc.html).

Of the three dates with high $PM_{2.5}$ concentrations in common to both counties, two days (1/10 and 1/16/04) exhibited similar ambient temperatures in contrast to the third day (12/12/05) which recorded relatively different temperatures. For the six, high $PM_{2.5}$ concentrations days in Ravalli County during 2004 - 2006, Table 15 characterizes the wind data (direction, average speed, and percentage of calms) measured by the Stevensville monitor. The wind data recorded in Missoula on their three high $PM_{2.5}$ concentration days in common with Ravalli County is also included in this table. Those three days in common were also emphasized in bold text under the Ravalli County section in Table 15.

**Table 15. Wind Data on High $PM_{2.5}$ Concentration Days in Ravalli & Missoula Counties, 2004 – 2005.**

| County (Site, ID) | Date | Percent of Time in Given Wind Direction (%) | | | | | | | | Average Speed (mph) | Percent Calm (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | NE | E | SE | S | SW | W | NW | | |
| Ravalli (Stevensville, 247894)[1] | 1/01/04 | 8.4 | 0.0 | 4.2 | 12.5 | 20.8 | 25.0 | 12.5 | 16.6 | 1.1 | 42 |
| | **1/10/04** | **12.5** | **20.8** | **37.5** | **12.5** | **12.5** | **0.0** | **4.2** | **0.0** | **1.4** | **8** |
| | **1/16/04** | **4.2** | **12.5** | **12.5** | **25.0** | **25.0** | **4.2** | **8.3** | **8.3** | **1.2** | **29** |
| | 1/10/05 | 12.5 | 20.8 | 4.2 | 16.7 | 12.5 | 20.8 | 8.3 | 4.2 | 0.7 | 50 |
| | 1/16/05 | 36.3 | 13.6 | 13.6 | 4.6 | 13.6 | 4.6 | 4.6 | 9.1 | 0.9 | 46 |
| | **12/12/05** | **16.7** | **12.5** | **8.3** | **8.3** | **29.2** | **8.3** | **12.5** | **4.2** | **1.0** | **29** |
| | ***OVERALL*** | ***15.1*** | ***13.4*** | ***13.4*** | ***13.3*** | ***18.9*** | ***10.5*** | ***8.4*** | ***7.0*** | ***1.1*** | ***34*** |
| Missoula (Missoula International Airport, 24153)[2] | 1/10/04 | 59.3 | 0.0 | 11.0 | 18.7 | 3.3 | 0.0 | 1.1 | 6.6 | 1.7 | 58 |
| | 1/16/04 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | < 1.0 | 0.0 | 0.0 | 0.1 | 99 |
| | 12/12/05 | 59.3 | 0.0 | 11.0 | 18.7 | 3.3 | 0.0 | 1.1 | 6.6 | 1.2 | 75 |
| | ***OVERALL*** | ***59.3*** | ***0.0*** | ***11.0*** | ***18.7*** | ***3.3*** | ***0.0*** | ***1.1*** | ***6.6*** | ***1.0*** | ***77*** |

[1] RAWS USA Climate Archive. ONLINE: (http://www.raws.dri.edu/).
[2] National Climatic Data Center. Monthly Summary. ONLINE: (http://www.ncdc.noaa.gov/oa/ncdc.html).

Generally, days with high $PM_{2.5}$ concentrations have extremely low wind speeds accompanied with a high percentage of calm winds. This situation is especially common in the Missoula Valley. In the Bitterroot Valley, winds swirl about with no dominant direction. Under these conditions, it's highly unlikely for emissions to exchange between either county. It's highly probable that both counties experience the same atmospheric conditions, e.g. high pressure, which produce strong temperature inversions and result in high ambient $PM_{2.5}$ concentrations.

## Factor 7: Geography and Topography

Ravalli County is located on the western edge of Montana in a protected valley know locally as the 'Bitterroot Valley'. The Bitterroot Valley is orientated north-south between two mountain ranges: the Sapphires to the east and the Bitterroots to the west. The elevations range from 3,200 feet at the north end of the valley to 10,157 feet (ft) on Trapper Peak in the mountains at the south end of the valley. The elevations at the airports in Hamilton and Stevensville are 3,642 and 3,610 ft, respectively.[13] The Bitterroot Valley is approximately 96 miles long and 20 miles wide at its mid-section, covering 2,394 square miles of land area. The Bitterroot River runs north from its source until it empties into the Clark Fork River in the Missoula Valley.

As seen in Figure 6, the topographic changes vary considerably between the northern and southern portions of the Bitterroot Valley. The isopleths in Figure 6 indicate elevations of 4,000, 5,000, and 7,000 feet. The northern end of the Bitterroot Valley is relatively flat and open, considerably wider than the southern portion with panoramic views overlooking agricultural land and towns. The southern end of the Bitterroot Valley narrows and is barely five miles wide where the Bitterroot River splits into the East and West Forks. The steep gradient of many hills prevents development since the Ravalli County subdivision regulations prohibits construction on any slopes 25% or greater (Cyra Cain, DEQ, personal communications, John Lavey, Ravalli County, October 1, 2007).

The topographic features surrounding Ravalli County make several of the nine factors insignificant for this proposed nonattainment area boundary analysis, especially those addressing adjacent population centers. For example, the entire Bitterroot Valley is outlined with mountains on either side. To the west lies the Bitterroot Mountain Range and the Selway-Bitterroot Wilderness Area. The west side of the valley is cut with numerous deeply-carved granite canyons, such as Blodgett Canyon. The nearest population center is the Lewiston-Orofino-Grangeville Idaho area located approximately 130 miles due west of Hamilton. To the south and east, the Sapphire Mountains and the Anaconda-Pintler Wilderness Area are also without significant population centers.

These topographic features and few surrounding population centers limit the predominant sources of particulate emissions to area sources within the Bitterroot Valley or those affecting the valley from adjacent forest lands in the form of smoke from outdoor burning or wildfires. As previously noted, particulate emissions from wildfires cannot be considered for determining nonattainment boundaries. However, for conservative purposes, DEQ included all of the forested lands in the public domain within the proposed Ravalli County $PM_{2.5}$ nonattainment area.

[13] AirNav.Com. Ravalli County and Stevensville airports. ONLINE: (http://www.airnav.com/airport/6S5 and http://www.airnav.com/airport/32S).

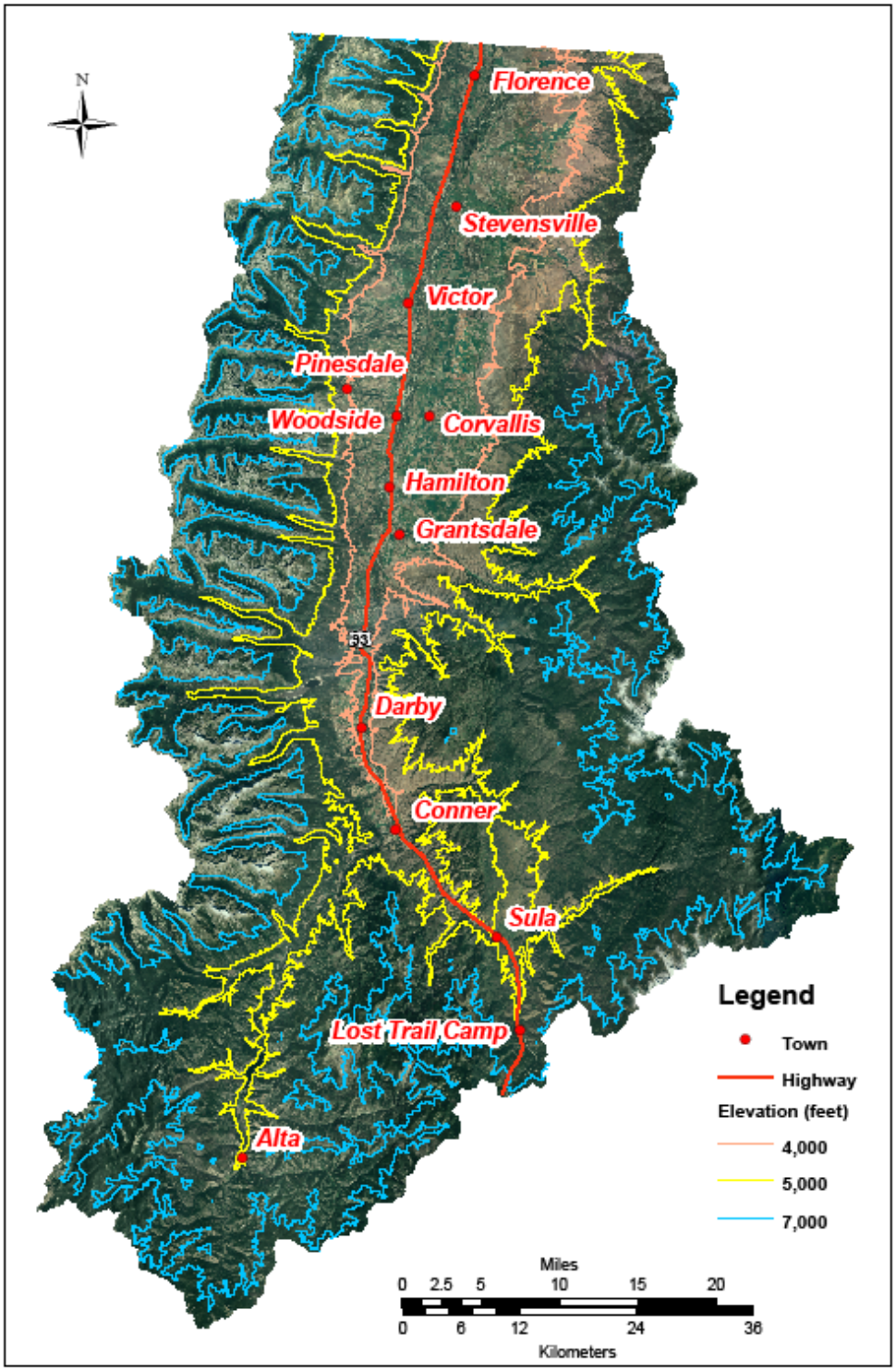


**Figure 6. Map of Ravalli County Topography.**

## Factor 8: Jurisdictional Boundaries

Given the nature of $PM_{2.5}$ as a regional rather than localized pollutant, the Ravalli County $PM_{2.5}$ NAA will extend north to the Missoula-Ravalli County line and be contiguous with the boundary of the Missoula $PM_{2.5}$ NAA. This action may create the potential for jurisdictional and enforcement opportunities and/or difficulties because these NAA remain under the separate jurisdictions of each county.

This necessity of maintaining separate NAA allows each county to develop strategies to reduce $PM_{2.5}$ pollution that are most appropriate to each individual county and to implement processes that recognize the regulatory, political, and financial realities specific to each county.

Missoula and Ravalli Counties are not only physically separate, but the history of air pollution and regulation within each county is considerably different. Missoula has a long history of both severe air pollution and extensive experience in the implementation of a formal air quality program and regulations. In contrast, Ravalli County, to date, does not have an air pollution control program operating within the county. Missoula County is currently designated as nonattainment for particulate matter less than or equal to 10 microns ($PM_{10}$) and is in maintenance status for Carbon Monoxide (CO).

Notably, the current and former NAA boundaries for these pollutants center on the city of Missoula, and do not include the more remote parts of the county. Missoula County implemented control measures to reduce the emissions of both of these pollutants, and has not violated either of these standards since the early 1990s. In fact, the Missoula County CO NAA was officially redesignated to attainment on August 17, 2007 at 72 FR 46158. By contrast, Ravalli County has not been designated as nonattainment for any air pollutant.

Additionally, the nature of $PM_{2.5}$ exceedances differs in each county. Therefore, control measures may differ as well. Each county understands the causes of air pollution within its own boundaries and also possesses the best understanding of the political landscape. Both counties will collaborate on control measure development with DEQ taking the lead role to help facilitate collaboration between counties.

## Factor 9: Level of Existing Control of Emission Sources

No permitted major source with emissions exceeding 250 tons per year of any regulated pollutant is located within Ravalli County. However, three minor sources were permitted in the county during 2004-06: Bitterroot Pet Crematorium (AIRS #30-081-006), Rocky Mountain Laboratories (AIRS #30-081-005), and Specialty Surgical Products, Inc. (AIRS # 30-081-007). The acronym AIRS represents Aerometric Information Retrieval System. The Air Facility Subsystem (AFS) portion of the AIRS database is dedicated to tracking the information associated with permitted stationary sources of air pollution. These three facilities and associated emissions in tons per year for each year are given in Table 16. The listed air pollutants in is this table are sulfur dioxide ($SO_2$), nitrogen dioxides ($NO_2$), volatile organic compounds (VOC), ammonia ($NH_4$), and $PM_{10}$. Since DEQ did not require reporting of fine particulates during the 2004 - 2006 time period, the particulate emissions in the AFS database were inventoried as $PM_{10}$, not $PM_{2.5}$.

**Table 16. Estimated Actual Annual Emissions from DEQ-Permitted Minor Sources in Ravalli County for 2004-06.**[1]

| Source | Pollutant (tons per year) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004 | | | | | | 2005 | | | | | | 2006 | | | | | |
| | $SO_2$ | $NO_2$ | VOC | $NH_3$ | $PM_{10}$ | Total | $SO_2$ | $NO_2$ | VOC | $NH_3$ | $PM_{10}$ | Total | $SO_2$ | $NO_2$ | VOC | $NH_3$ | $PM_{10}$ | Total |
| Bitterroot Pet Crematorium | 0.02 | 0.05 | < 0.01 | | 0.02 | 0.09 | 0.02 | 0.06 | < 0.01 | | 0.03 | 0.11 | 0.02 | 0.05 | < 0.01 | | 0.02 | 0.09 |
| Rocky Mountain Labs | 0.52 | 8.28 | 0.85 | 0.22 | 0.42 | 10.29 | 0.56 | 8.18 | 0.94 | 0.21 | 0.48 | 10.37 | 1.93 | 13.09 | 1.16 | 0.23 | 0.63 | 17.04 |
| Specialty Surgical Products, Inc. | | | 13.36 | | | 13.36 | | | 8.48 | | | 8.48 | | | 6.77 | | | 6.77 |

[1] DEQ. Emission Inventory Summary. DEQ Air Resources Management Bureau.

Combing all three minor industrial sources together, the total amount of emissions was less than 25 tons per year, regardless of the year. The DEQ believes these sources do not contribute a significant amount of $PM_{2.5}$ emissions within the Bitterroot Valley airshed.

Figure 7 show the locations of the permitted industrial point sources, the local communities, the wilderness areas, and the U.S. Highway 93 in Ravalli County.

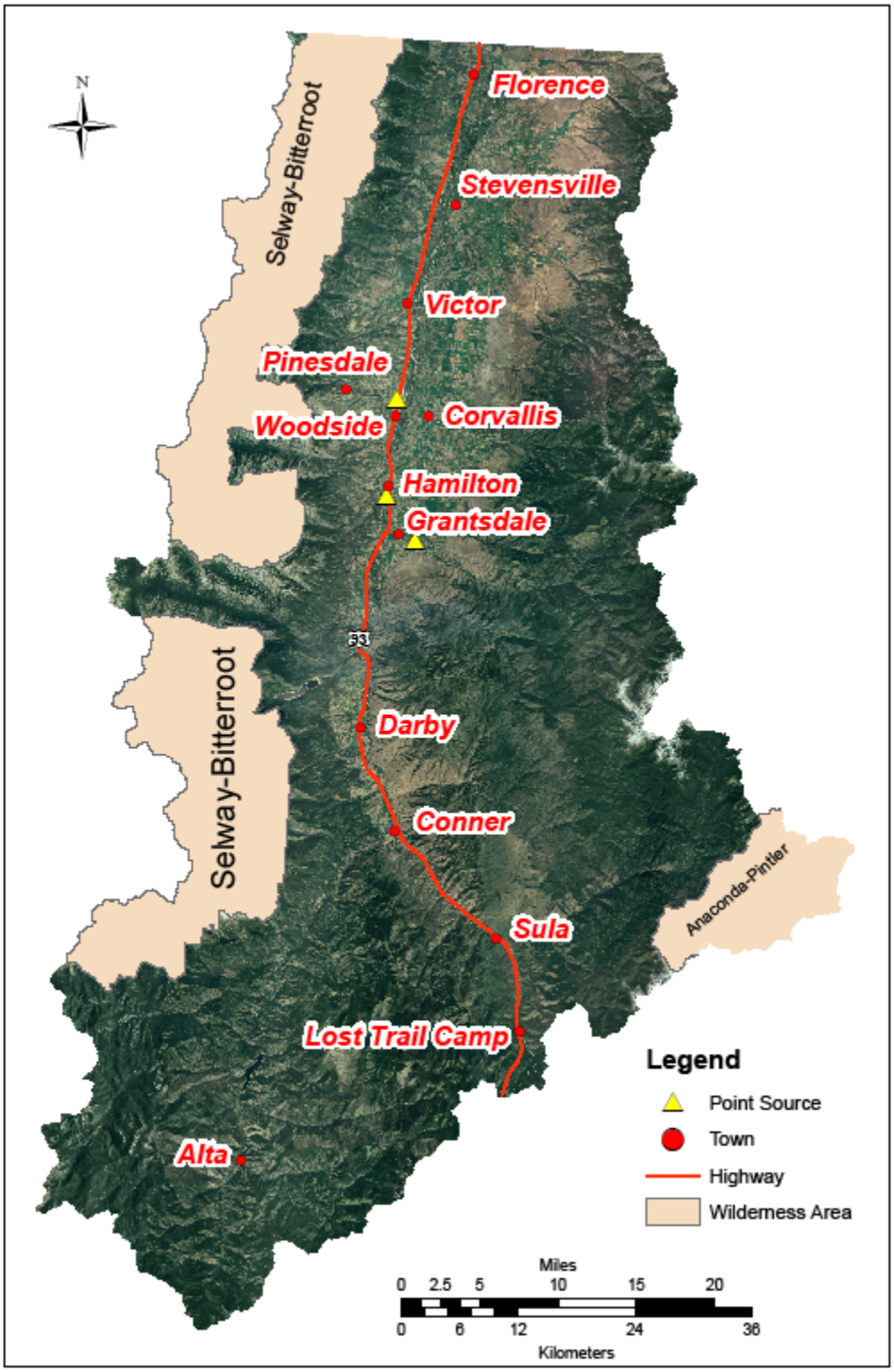


**Figure 7. Industrial Point Sources and Wilderness Areas in Ravalli County.**